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METHOD FOR MANUFACTURING OF A CATHODE SUSPENSION BAR

The present invention relates to a method for manufacturing a suspension bar for a permanent cathode used in the electrolysis of metals, wherein the suspension bar is formed of a rigid metal outer jacket and a highly conductive core attached inside it. By this method, a good connection is achieved between the outer jacket and the core. This connection is made by drawing, upsetting, melting or casting.

In the electrolysis of metals, a traditional method involves the use of starting sheets which are first grown on the surfaces of mother plates. Using this kind of starting sheets then as cathodes which are of the same metal as the metal to be precipitated, eg copper, is being phased out especially when new investments are concerned. When building new electrolysis tank houses, the trend has been towards the use of permanent cathodes and the sheet-like part of the cathode is generally is made from acid-resistant steel or titanium.

Permanent cathodes have been manufactured in many different ways, the principal difference being in the structure of the cathode suspension bar and the fastening of the plate part to the suspension bar. The structure of the suspension bar and attaching the plate part are problematic in that in order to conduct a large electric current to the plate part, there has to be enough copper in the suspension bar. Since acid-resistant steel is a poor conductor, it cannot be the sole material used in the bar.

There are several methods in the prior art to solve the combination of copper and another metal in the manufacture of the suspension bar of permanent cathodes. The commercial market is dominated by two forms of construction. The first of these uses an all-copper suspension bar, to which an acid-resistant steel plate part is welded using a specially alloyed welding

wire. One drawback of this method is the softness of a suspension bar made wholly of copper, as a consequence of which the bar is easily deformed, especially if larger cathode weights are used. A temperature increase caused by short circuits further exacerbates this problem.

A second disadvantage of the all-copper suspension bar is that it is difficult to attach separate lifting lugs firmly enough to the suspension bar, which lifting lugs will be on the top of the suspension bar as required by state-of-the-art material handling. The third disadvantage is that the special alloy welding required for attaching the acid-resistant steel plate part and the copper suspension bar is not at all as corrosion-resistant as the other parts of the cathode. The advantages of this construction are that making this kind of permanent cathode is quick, requires low investments and there are no special demands as to the location of the fabrication process. Another advantage is the large cross-sectional area of copper in the suspension bar, which leads to low resistance and consequently low power losses in the actual structure of the permanent cathode.

In the second, widely used construction of a permanent cathode suspension bar, a tubular suspension bar core is made of stainless or acid-resistant steel. An acid-resistant plate part is welded with welding wire conventional to these materials. After being attached, the suspension bar and the uppermost part of the plate part, where the welds are located, are plated electrolytically with copper in order to achieve adequate electroconductivity. Copper plating also protects the welds from environmental impact. This method is described for example in GB patent 2,040,311.

The most notable disadvantage of the method described above is that the electrolytic plating requires a long time, several days, as a result of which production throughput time increases considerably and the electroplating demands large investments in equipment. Because of the electroplating,

the fabrication line must be in the immediate vicinity of an operational electrolysis tankhouse. In this construction, the cross-sectional surface of the copper is smaller than for example in the previously described construction, where the suspension bar is all copper. This in turn leads to the presently described permanent cathode having a slightly higher resistance in its own construction and the ensuing energy losses are greater than when an all-copper suspension bar is used. On the other hand, a steel-core suspension bar does have great durability whereby the permanent cathode will keep its shape well even with great cathode weights, nor do short-circuits cause problems to the life time of the cathode. It is also much easier to attach the above-mentioned separate lifting lugs to this kind of construction. The lifting lugs are welded secure to the steel core of the bar before electrolytic copper plating, which makes the construction strong and durable. In this design, all welds occur between the steel parts and remain under the copper plating, thereby making the connections strong and longlasting.

US patent 4,647,358 describes a further permanent cathode, where the outermost part of the suspension bar is manufactured from steel pipe, attached to the plate part by welding. A hollow copper pipe is placed inside the suspension bar steel pipe, which is either longer than the steel pipe or the steel pipe is at least partially open at the ends so that the current flow occurs via the copper inner pipe of the suspension bar. The internal diameter of the steel pipe is almost that of the outer diameter of the copper pipe so that the pipes are in close contact with each other. The outer jacket, of which the manufacturing method is described in the patent, is initially open longitudinally so that the inner tube is easier to position and after installing the inner pipe the outer jacket is attached to the pipe longitudinally by welding. Both the inner pipe and outer jacket at the ends of the bar are welded to each other.

Advantages of the previously described method are the great strength of the bar and also that both the cathode plate part and the separate lifting lugs can be welded directly to the jacket section which is of the same metal. The disadvantage however, is that, in order to achieve proper contact, separate welds and/or blanking between the jacket and the core are required. As a result, in large production quantities it is difficult to get bars of uniform quality. Another disadvantage is that the jacket and the core have to be welded together at the ends so that the construction will be tight and not exposed to corrosion, since any electrolyte getting between the jacket and the core is not good for the long-term durability of the bar. Production therefore requires numerous working steps that are difficult to automate, so that the high costs of production become a problem and as already mentioned, the assurance of uniform quality may be overwhelming.

Summary of Invention

This invention focuses on a method to manufacture a permanent cathode suspension bar used in the electrolysis of metals, whereby the suspension bar is fabricated from a rigid metal outer jacket inside which a highly electroconductive core is placed either by drawing, upsetting, melting or casting. The aim of these techniques is to achieve a sufficiently good electrical contact and tightness between the jacket and the core without any additional working steps. The most preferable is to achieve a metallurgical bond between the parts of the bar. Thus, it is enough, after joining the jacket and the core, that the jacket is machined partially open at one end at least to generate a good electrical contact between the cathode suspension bar and the tank busbar. The essential features of the invention will become apparent in the attached patent claims.

The text mainly refers to copper as the highly electroconductive core metal, but it can also be aluminium. The rigid metal outer jacket is preferably manufactured from refined steel so that it may be acid-resistant or stainless steel.

When the suspension bar is formed by drawing, a highly electroconductive core is made for the bar by drawing copper through the inside of the ready outer jacket. When the outer jacket is for example made of refined steel, the easiest way is to do it beforehand, as refined steel is difficult to draw. This will preferably happen so that a tubular preform suitable for the inside of the steel jacket is made of copper. This preform is put inside the steel jacket and an arbor is drawn through the hole in the copper preform in the drawing machine, which forces the copper tightly against the surface of the steel jacket. A steel bar can also be used as an arbor either drawn or pushed into the hole in the copper preform and if required can also be left inside the finished bar. During production, the steel jacket can, if necessary, be supported from outside in order to prevent deforming. The shaping of the copper and its binding to the steel can be affected by adjusting the temperature.

upsetting

A permanent cathode suspension bar can also be fabricated by upsetting, whereby a suitable core is set inside the outer jacket so that by pressing the ends of the core it may be extruded very tight to the jacket at least at the important places i.e. at the ends. The temperature can be adjusted to favour the shaping of the copper as in drawing. Depending on the temperature used, a metallurgical contact between the jacket and the core can be made also by drawing or upsetting.

Fabricating of the suspension bar by melting is done so that a copper core preform which is beforehand made by, for example, casting, drawing or machining, is first put in solid form inside the steel jacket and then melted there by heating the jacket and the core preform. Melting can be done in a vertical position when it is preferential to plug the lower end of the steel tube. Then the tube both supports the core preform and retains the molten copper inside the jacket tube. During the heat treatment, the jacket remains

in sufficiently solid form. The bond between steel and copper can be adjusted with the temperature and with the time the copper is kept in molten condition, and by using a suitable combination a metallurgical bond is achieved.

When the suspension bar is fabricated by casting, it is done so that the outer jacket of steel tube acts as a mould inside which the copper core is cast directly. However, the jacket remains in sufficiently solid form. Any potential adhering of the copper to the outer surface of the steel jacket can be prevented by, for example, graphite solution treatment or some other coating. By casting molten copper inside the solid steel jacket, a reliable metallurgical bond between the steel and the copper can be formed.

The casting itself occurs e.g. by pouring molten core metal inside an upright steel tube, which is closed at the lower end. It is preferable to preheat the steel jacket powerfully or to additionally heat the whole bar (jacket + core) after pouring the melt. It is essential that the jacket is enough long time in actual contact with the molten copper so that a metallurgical bond has time to form between the jacket and the core. If the jacket tube is not heated in advance, or the whole bar during or after casting, there will be no cracking, but the core metal will solidify so quickly on the cold inner wall of the jacket that no bond will be form.

Another method of filling the steel jacket is to immerse it in copper melt for enough long time when preheating is maybe not necessary at all. Immersion can be made with the tube in a horizontal position, in which case before immersing the steel jacket both ends are plugged and a sufficient number of holes are made in the upper side of the tube for the feed of the copper and the release of air. A suitable amount is for example one hole at either end of the tube. The tube may also be held in an inclined position to ensure the melt fills the inside. Immersion may also of course be made in a vertical

position, wherein only the lower end of the steel jacket is plugged before immersion. For example, immersion for approximately one minute is sufficient to obtain a good end result.

As previously found, a contact of good electroconductive metals is desired between the permanent cathode and the electrolytic tank busbar, so that the current flows between them with little loss. This is easy to achieve with a drawn, upset, smelted or cast core so that, for example, after connecting the parts of the bar, the steel jacket can be removed from one side of the bar, at either both ends or only one end, at a suitable length from the face of the copper core. At the same time, the cross-sections of the copper contact of the bar can be formed to the required shape, for instance, cambered.

Separate lifting lugs made of refined steel are welded as required directly to the steel jacket of the suspension bar. Likewise, the cathode plate part is welded directly to the steel jacket. The plate part and lifting lugs can be attached to the suspension bar steel jacket either before the copper core is attached or afterwards and the welds are always made joining pieces of the same material so they are easy to do and durable.